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(54) **ACCESSORY DEVICES DRIVE SYSTEM**

(56) **References Cited**

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U.S. PATENT DOCUMENTS

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2,883,020 A * 4/1959 Kummich F16D 11/10
192/114 R
3,045,790 A * 7/1962 Becker F16D 13/20
192/38
4,145,888 A 3/1979 Roberts
4,303,151 A * 12/1981 Kolacz F16D 11/12
192/114 R
4,351,204 A * 9/1982 Ross B60K 25/00
475/171
4,542,722 A * 9/1985 Reynolds F02B 67/04
123/179.19
5,558,173 A 9/1996 Sherman
5,700,212 A * 12/1997 Meckstroth B60K 25/02
474/69
6,177,734 B1 * 1/2001 Masberg B60K 6/26
290/31
6,464,028 B1 10/2002 Imani

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US 2014/0290406 A1 Oct. 2, 2014

(Continued)

OTHER PUBLICATIONS

International Search Report for PCT/US2013/065165, mailed Jan. 27, 2014 by the Korean Intellectual Property Office.

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F16D 41/06 (2006.01)
F16D 15/00 (2006.01)
F16D 41/061 (2006.01)
F16D 41/063 (2006.01)
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(2015.01)

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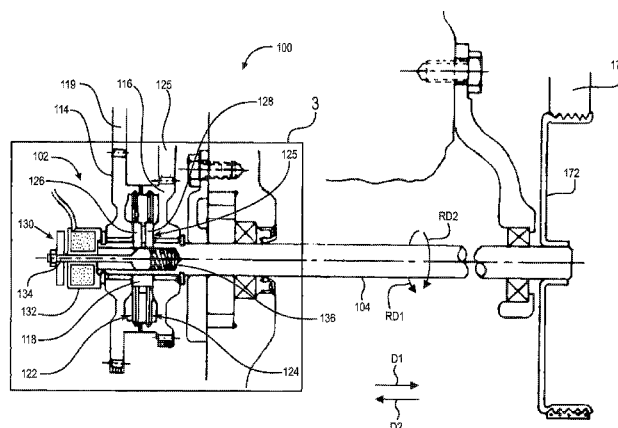
CPC F02B 67/04; F02B 67/06; F16D 41/061;
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(57) **ABSTRACT**

An accessories drive system, including: a clutch assembly with a drive shaft; and at least one accessory device connected to the drive shaft. In a first position for the clutch assembly: the clutch assembly is arranged to transmit first torque from an output shaft for a transmission to the drive shaft to drive the at least one accessory device and rotation of the drive shaft is isolated from rotation of a launch device for the vehicle. In a second position for the clutch assembly: the clutch assembly is arranged to transmit second torque from the launch device to the drive shaft to drive the at least one accessory device and the rotation of the drive shaft is isolated from rotation of the output shaft for the transmission.

18 Claims, 7 Drawing Sheets



US 9,447,726 B2

Page 2

(56)

References Cited

U.S. PATENT DOCUMENTS

6,668,953	B1 *	12/2003	Reik	B60K 6/08	2007/0111849	A1	5/2007	Ji	
				180/165	2008/0096711	A1	4/2008	Smith et al.	
					2008/0149448	A1 *	6/2008	Hemphill	F16D 41/063
									192/45.1
6,942,048	B2	9/2005	Ishikawa et al.		2009/0101465	A1	4/2009	Hart et al.	
9,046,140	B2 *	6/2015	Davis	F16D 41/08	2011/0053729	A1	3/2011	Parsons et al.	
2003/0116118	A1 *	6/2003	Tonnqvist	B60K 6/24	2013/0035193	A1 *	2/2013	Janson	F02B 67/04
				123/198 R					475/211
					2014/0014455	A1 *	1/2014	Davis	F16D 41/063
									192/45.1
2003/0116368	A1	6/2003	Winkelman et al.						

* cited by examiner

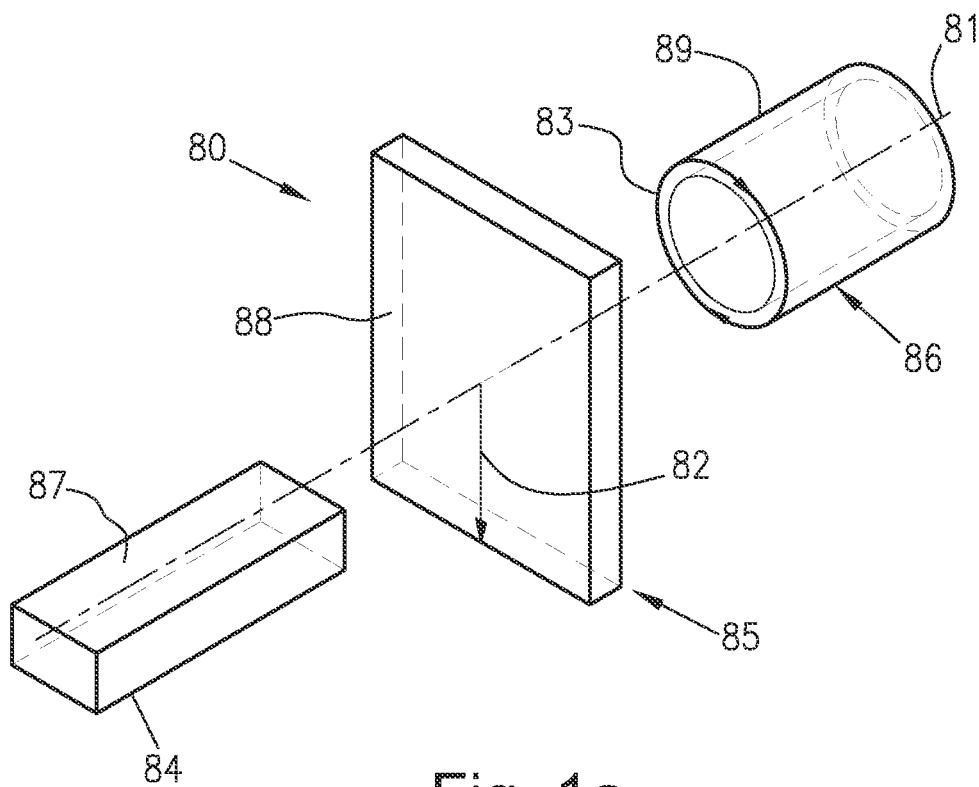


Fig. 1a

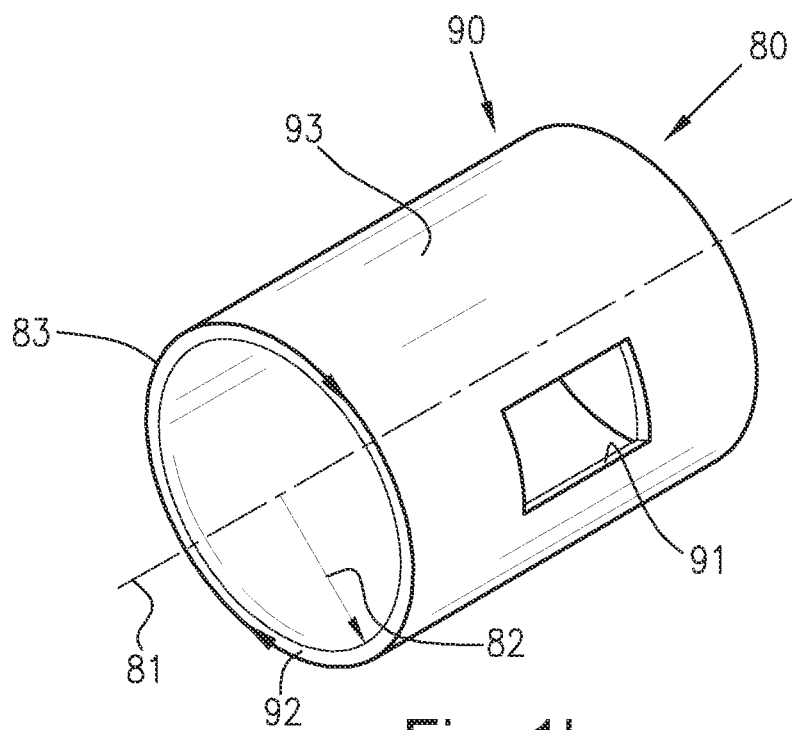


Fig. 1b

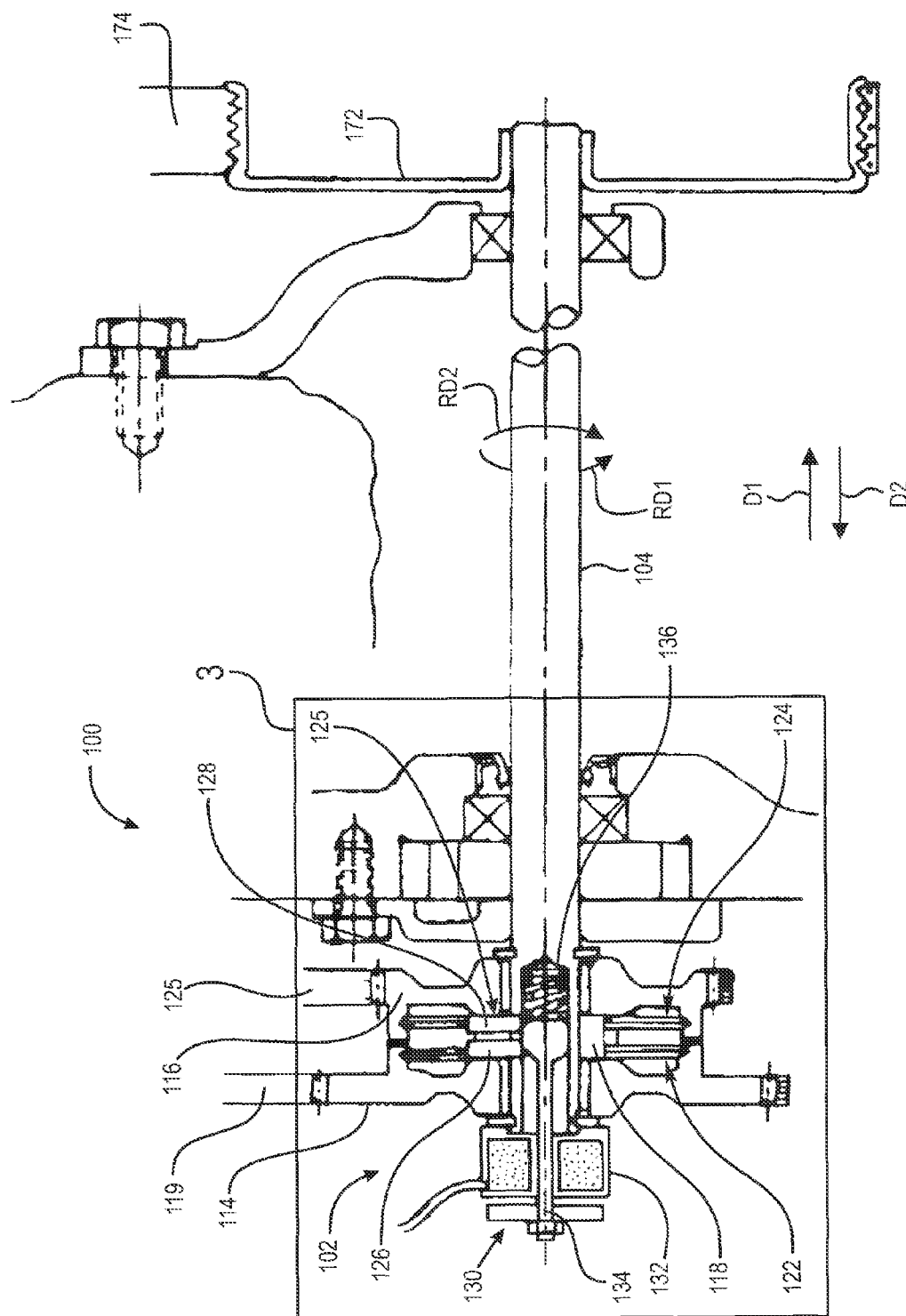


Fig. 2

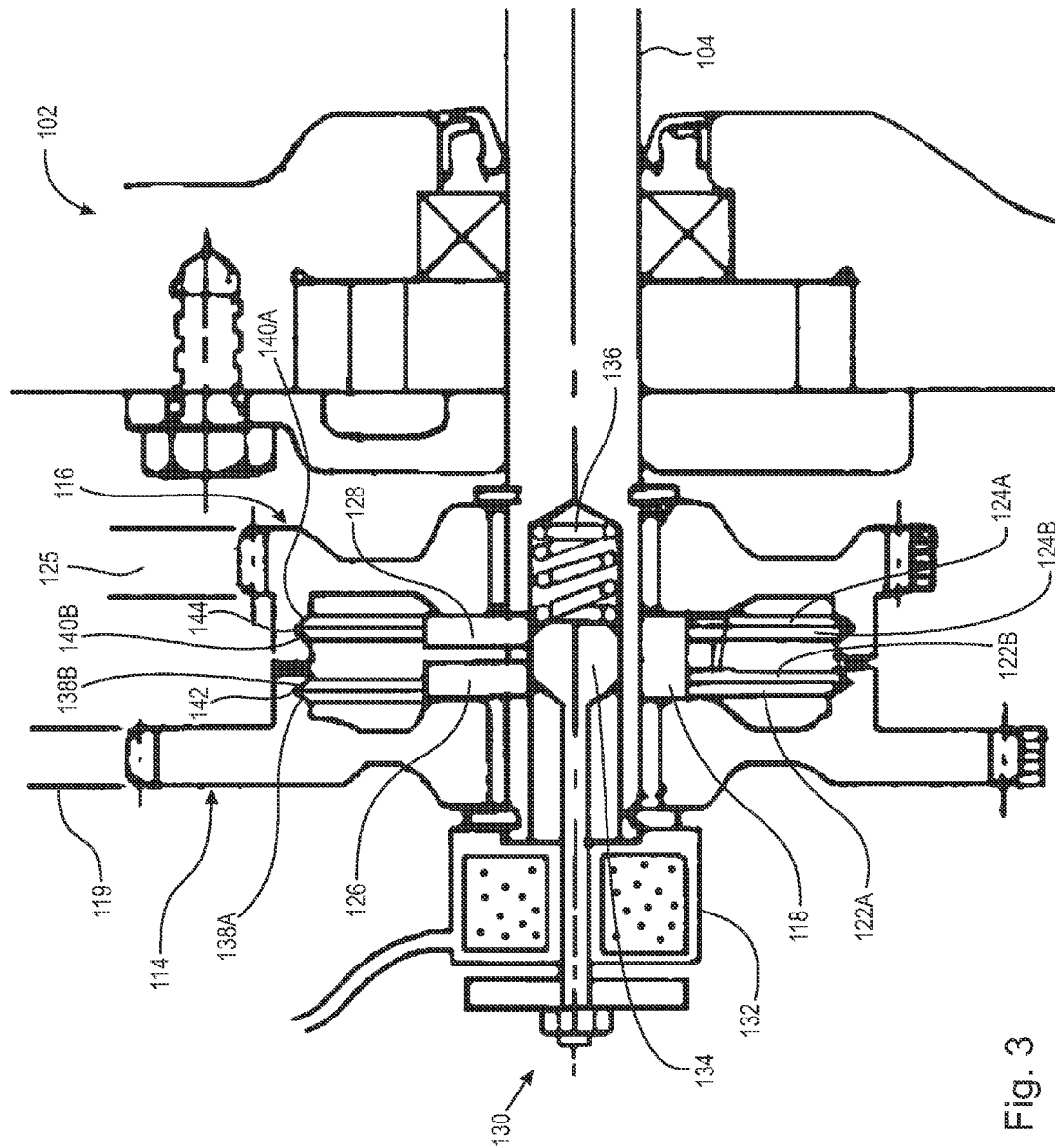


Fig. 3

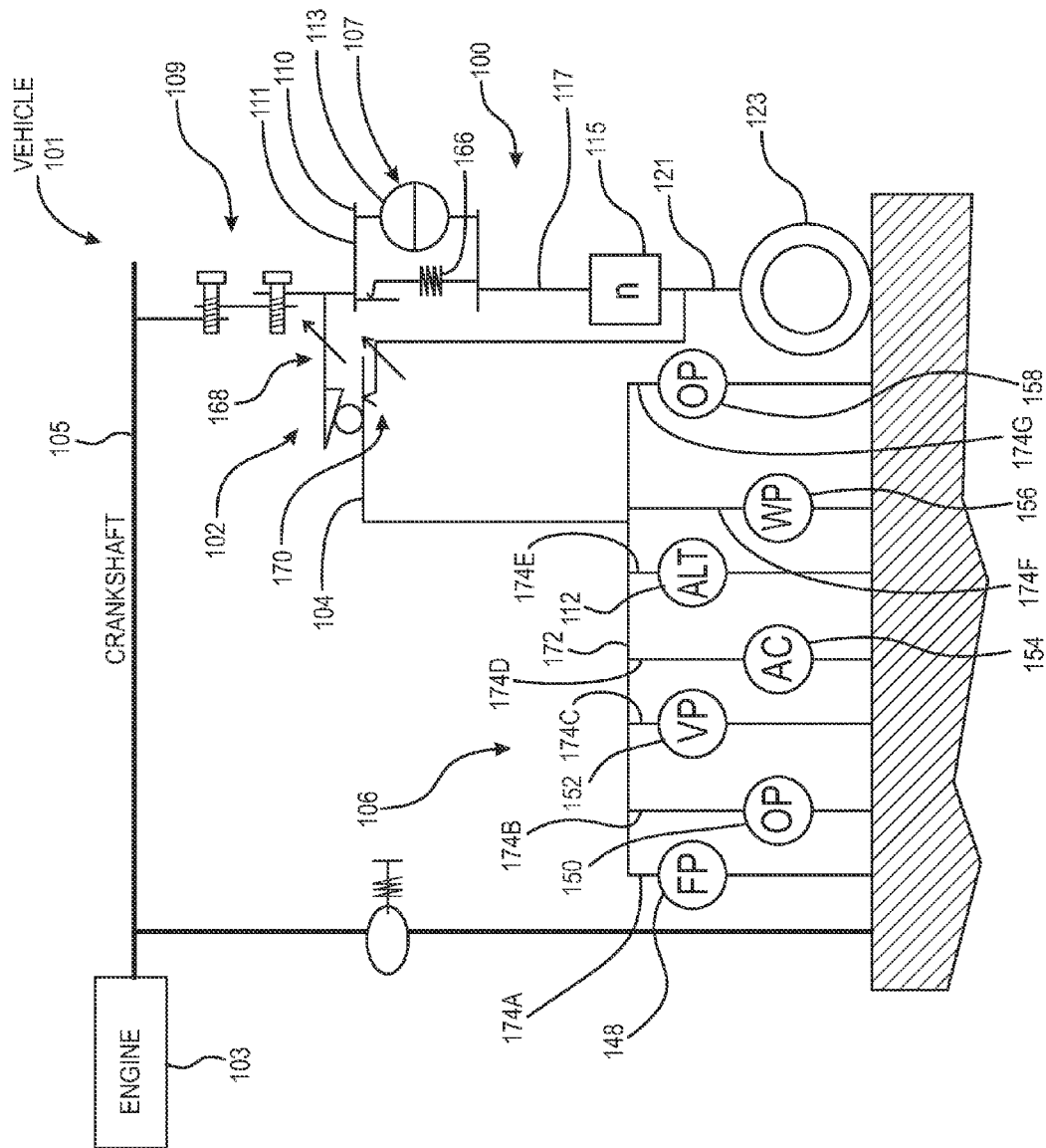


Fig. 4

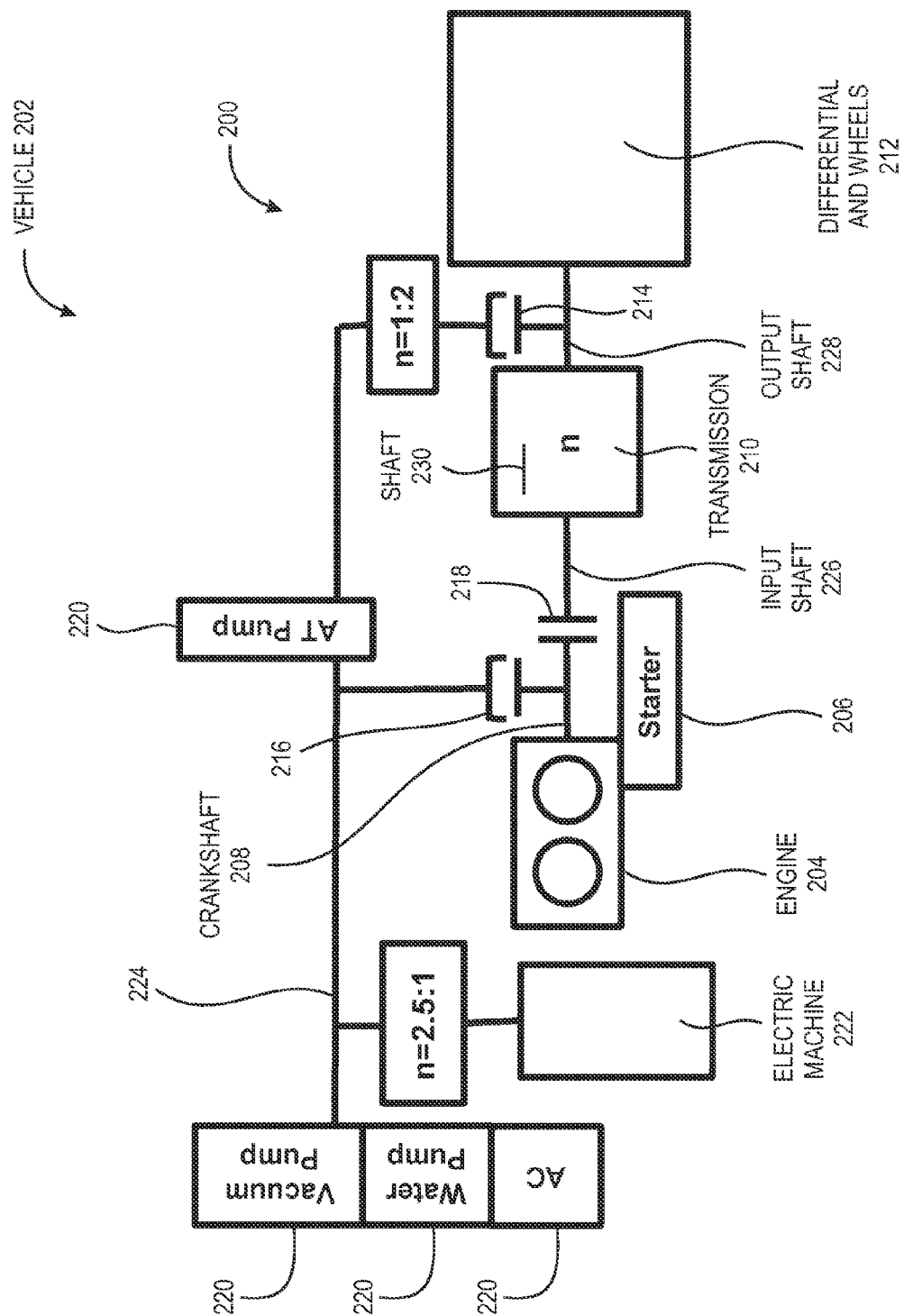


Fig. 5

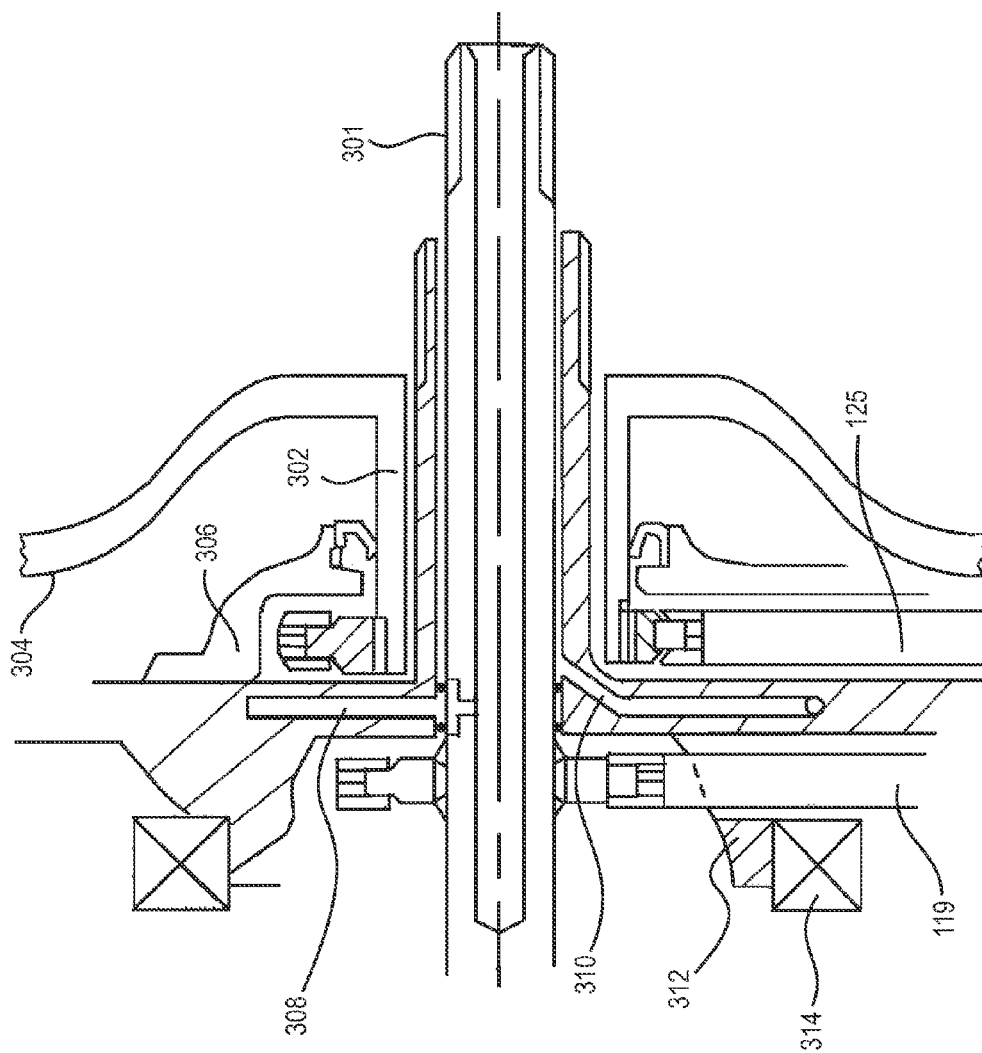


Fig. 6

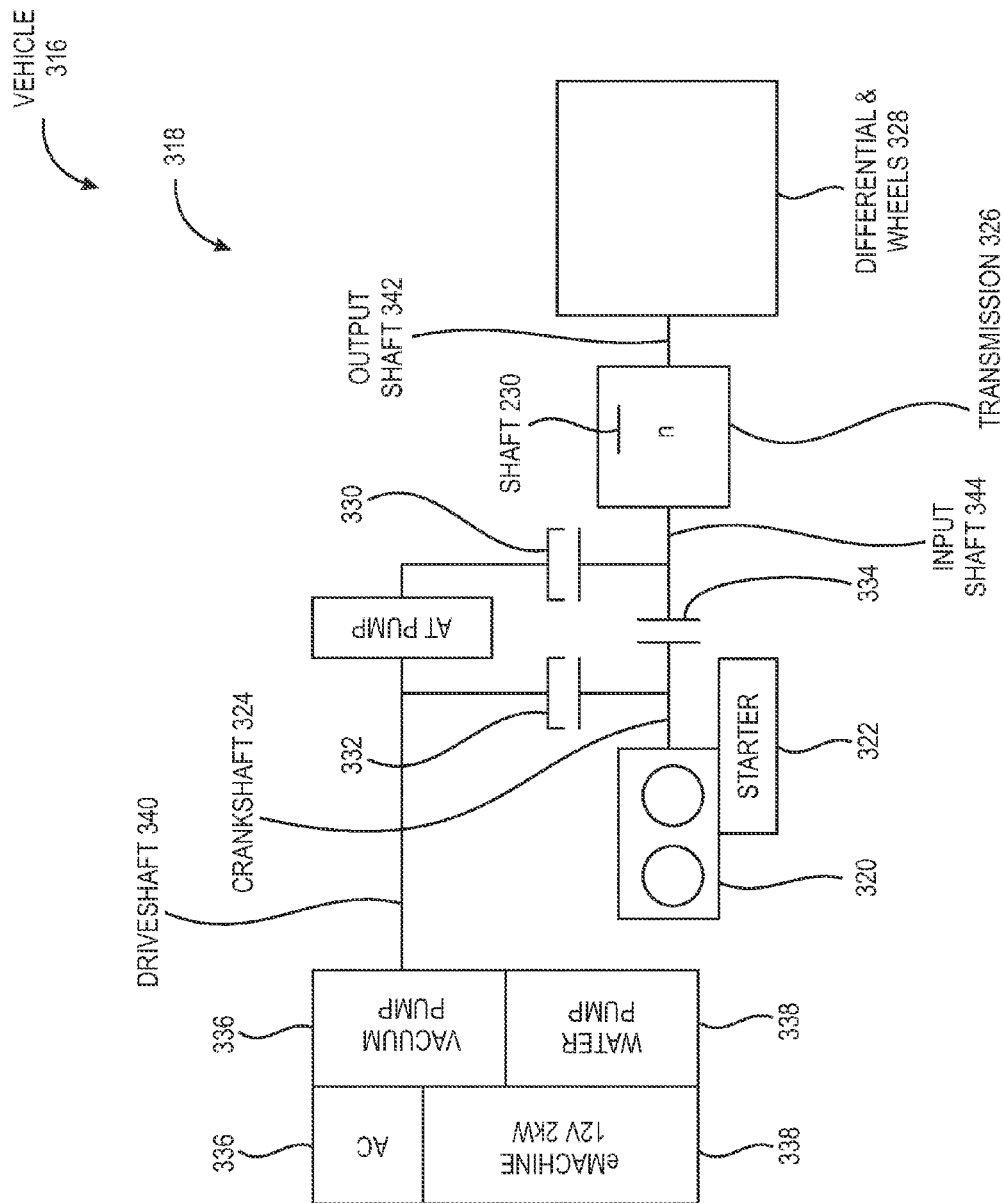


Fig. 7

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ACCESSORY DEVICES DRIVE SYSTEM**CROSS-REFERENCES TO RELATED APPLICATIONS**

This application claims the benefit under 35 U.S.C. §119 (e) of U.S. Provisional Patent Application No. 61/805,356 filed Mar. 26, 2013, which application is incorporated herein by reference in its entirety.

TECHNICAL FIELD

The present disclosure relates to a system for driving accessory devices for a vehicle, in particular, a system driving the accessory devices using an output of a crankshaft, a transmission shaft, or an electric machine.

BACKGROUND

It is known to drive accessory devices for a vehicle, such as an alternator, water pump, or oil pump, using belts and pulleys driven by the crankshaft of the engine for the vehicle. Thus, the rotational speeds for the accessory devices have fixed ratios with respect to the rotational speed of the crankshaft. The accessory devices are normally sized to deliver full output at engine idle speed in order to allow full functionality at idle speed. As a result, during normal operation of the vehicle, when the crankshaft is rotating at speeds greater than the idle speed rotation, the accessory devices are being rotated much faster than required. Further, when the engine is turned off, the accessories come to a stop, which creates problems for stop-start and hybrid capable vehicles.

SUMMARY

According to aspects illustrated herein, there is provided an accessories drive system, including: a clutch assembly with a drive shaft; and at least one accessory device connected to the drive shaft. In a first position for the clutch assembly: the clutch assembly is arranged to transmit first torque from a shaft for the transmission to the drive shaft to drive the at least one accessory device and rotation of the drive shaft is isolated from rotation of a crankshaft for the vehicle. In a second position for the clutch assembly: the clutch assembly is arranged to transmit second torque from the crankshaft to the drive shaft to drive the at least one accessory device and the rotation of the drive shaft is isolated from rotation of the shaft for the transmission.

According to aspects illustrated herein, there is provided an accessories drive system, including: an electric machine; a clutch assembly connectable to a shaft for the transmission and a crankshaft for the vehicle and including a drive shaft; and at least one accessory device connected to the drive shaft. In a first position for the clutch assembly, the clutch assembly is arranged to transmit first torque from the shaft for the transmission to the drive shaft to drive the at least one accessory device. In a second position for the clutch assembly, the clutch assembly is arranged to transmit second torque from the crankshaft to the drive shaft to drive the at least one accessory device. In a third position for the clutch assembly, the electric machine is arranged rotate the drive shaft to drive the at least one accessory device.

According to aspects illustrated herein, there is provided an accessories drive system, including: an electric machine; and a clutch assembly including: a drive shaft; a first drive element connectable to a shaft for the transmission; a second

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drive element connectable to a crankshaft for the vehicle; and a drive hub non-rotatably connected to the drive shaft. The drive system includes at least one accessory device connected to the drive shaft. In a first position for the clutch assembly: the first drive element is arranged to transmit first torque from the shaft for the transmission to the drive shaft to drive the at least one accessory device; and the drive shaft is rotatable with respect to the second drive element. In a second position for the clutch assembly: the second drive element is arranged to transmit second torque from the crankshaft to the drive shaft to drive the at least one accessory device; and the drive shaft is rotatable with respect to the first drive element. In a third position for the clutch assembly: the drive shaft is rotatable with respect to the first and second drive elements; and the electric machine is arranged to rotate the drive shaft to drive the at least one accessory device.

According to aspects illustrated herein, there is provided a vehicle, including: an engine; a crankshaft connected to the engine; a torque converter including a cover and an output; a connection element non-rotatably connecting the crankshaft and the cover; a transmission including an output shaft and an input shaft non-rotatably connected to the output of the torque converter; and at least one accessory device. In a first mode of operation for the vehicle, the at least one accessory device is driven by the transmission at a rotational speed of the output shaft and rotation of the drive shaft is isolated from rotation of the crankshaft. In a second mode of operation for the vehicle, the at least one accessory device is driven by the engine at a rotational speed for the crankshaft; and rotation of the drive shaft is isolated from rotation of the output shaft.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments are disclosed, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, in which:

FIG. 1A is a perspective view of a cylindrical coordinate system demonstrating spatial terminology used in the present application;

FIG. 1B is a perspective view of an object in the cylindrical coordinate system of FIG. 1A demonstrating spatial terminology used in the present application; and,

FIG. 2 is a cross-sectional view of an accessories drive system;

FIG. 3 is a detail of area 3 of FIG. 2;

FIG. 4 is a schematic block diagram of a vehicle with an accessories drive system;

FIG. 5 is a schematic block diagram of a vehicle with an accessories drive system;

FIG. 6 is a cross-sectional view of a connection to an input shaft of a transmission for an accessories drive system; and,

FIG. 7 is a schematic block diagram of a vehicle with an accessories drive system.

DETAILED DESCRIPTION

At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the disclosure. It is to be understood that the disclosure as claimed is not limited to the disclosed aspects.

Furthermore, it is understood that this disclosure is not limited to the particular methodology, materials and modifications described and as such may, of course, vary. It is also

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understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present disclosure.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. It should be understood that any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the disclosure.

FIG. 1A is a perspective view of cylindrical coordinate system **80** demonstrating spatial terminology used in the present application. The present invention is at least partially described within the context of a cylindrical coordinate system. System **80** has a longitudinal axis **81**, used as the reference for the directional and spatial terms that follow. The adjectives “axial,” “radial,” and “circumferential” are with respect to an orientation parallel to axis **81**, radius **82** (which is orthogonal to axis **81**), and circumference **83**, respectively. The adjectives “axial,” “radial” and “circumferential” also are regarding orientation parallel to respective planes. To clarify the disposition of the various planes, objects **84**, **85**, and **86** are used. Surface **87** of object **84** forms an axial plane. That is, axis **81** forms a line along the surface. Surface **88** of object **85** forms a radial plane. That is, radius **82** forms a line along the surface. Surface **89** of object **86** forms a circumferential plane. That is, circumference **83** forms a line along the surface. As a further example, axial movement or disposition is parallel to axis **81**, radial movement or disposition is parallel to radius **82**, and circumferential movement or disposition is parallel to circumference **83**. Rotation is with respect to axis **81**.

The adverbs “axially,” “radially,” and “circumferentially” are with respect to an orientation parallel to axis **81**, radius **82**, or circumference **83**, respectively. The adverbs “axially,” “radially,” and “circumferentially” also are regarding orientation parallel to respective planes.

FIG. 1B is a perspective view of object **90** in cylindrical coordinate system **80** of FIG. 1A demonstrating spatial terminology used in the present application. Cylindrical object **90** is representative of a cylindrical object in a cylindrical coordinate system and is not intended to limit the present invention in any manner. Object **90** includes axial surface **91**, radial surface **92**, and circumferential surface **93**. Surface **91** is part of an axial plane, surface **92** is part of a radial plane, and surface **93** is a circumferential surface.

FIG. 2 is a cross-sectional view of transmission accessories drive system **100**.

FIG. 3 is a detail of area **3** of FIG. 2.

FIG. 4 is a schematic block diagram of a vehicle with transmission accessories drive system **100**. The following should be viewed in light of FIGS. 2 through 4. In an example embodiment, vehicle **101** includes engine **103**, crankshaft **105**, and transmission **115** with input shaft **117**, output shaft **121** to drive wheels **123**, and optional counter shafts, layshafts or concentric shafts. By “transmission” we mean a device for transmitting torque with an input shaft, an output shaft, and gearing for converting a rotational speed of the input shaft to a different speed at the output shaft. Transmission **115** may be a multi-speed planetary automatic transmission, a multi-speed manual gearbox, or a continuously variable transmission, for example. Vehicle **101** includes at least one accessory device **106**. In a first mode of operation for the vehicle, the at least one accessory device is driven by the engine at a rotational speed for the crankshaft. In a second mode of operation for the vehicle, the at

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least one accessory device is driven by the transmission at a rotational speed of one of the shafts of transmission **115**.

In an example embodiment, the vehicle includes accessories drive system **100** connected to crankshaft **105** and one of the shafts of the transmission, and including drive shaft **104**. The at least one accessory device **106** is connected to the drive shaft. In the first mode of operation for the vehicle, the accessories drive system is arranged to transmit first torque from one of the shafts of the transmission to the drive shaft to drive the at least one accessory device while rotation of the drive shaft is isolated from rotation of a crankshaft. In the second mode of operation, the accessories drive system is arranged to transmit second torque from crankshaft **105** to the drive shaft to drive the at least one accessory device while the rotation of the drive shaft is isolated from rotation of the shaft for the transmission.

In an example embodiment, vehicle **101** launch device **107** and connection element **109** non-rotatably connecting engine **103** and cover **111** of the launch device. In an example embodiment, launch device **107** is a wet or dry launch clutch or double clutch. In an example embodiment, launch device **107** is a torque converter. The discussion that follows is directed to torque converter **107**; however, it should be understood that the discussion is applicable to a launch device in general. Connection element **109** can include a flexplate. In an example embodiment, cover **111** is non-rotatably connected to pump **113** of the torque converter. Input shaft **117** is non-rotatably connected to an input of the torque converter, for example cover **111**, and output shaft **121** drives wheels **123**. In a first mode of operation for the vehicle, the at least one accessory device is driven by the engine at a rotational speed for the crankshaft. In a second mode of operation for the vehicle, the at least one accessory device is driven by the transmission at a rotational speed of output shaft **121** or one of the transmission counter shafts, layshafts or concentric shafts.

In an example embodiment, the vehicle includes accessories drive system **100** connected to the cover and output shaft **121** and including drive shaft **104**. The at least one accessory device **106** is connected to the drive shaft. In the first mode of operation for the vehicle, the accessories drive system is arranged to transmit first torque from output shaft **121** to the drive shaft to drive the at least one accessory device. In the second mode of operation, the accessories drive system is arranged to transmit second torque from cover **111** to the drive shaft to drive the at least one accessory device. In general, the portion of the launch device connected to system **100** rotates at the same speed as the crankshaft.

In an example embodiment, accessories drive system **100** includes clutch assembly **102**. As further described below, in a first position for the clutch assembly, the clutch assembly is arranged to transmit torque from output shaft **121** for transmission **115** to the drive shaft to drive the accessory device(s). As further described below, in a second position for the clutch assembly, the clutch assembly is arranged to transmit torque from cover **111** of torque converter **107**, for example, pump hub **110** of the torque converter, to the drive shaft to drive the accessory device(s). The pump hub is non-rotatably connected to pump **113**.

In an example embodiment, assembly **100** includes electric machine **112**. In a third position for the clutch assembly, the drive shaft is rotatable with respect to shaft **121** and cover **111** and the electric machine rotates the drive shaft to drive the at least one accessory device. By “electric machine” we mean an electrical device capable of generat-

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ing electrical current, for example, to charge a battery and/or capable of producing torque, for example an electric motor.

In an example embodiment, the clutch assembly includes drive element **114** arranged to transmit torque from the output shaft. Drive element **114** is connectable to the output shaft, for example via chain or belt **119**. In an example embodiment, the clutch assembly includes drive element **116** arranged to transmit torque from cover **111**. Drive element **116** is connectable to cover **111**, for example via chain or belt **125**. In the first position, drive element **114** is arranged to transmit torque from the output shaft to the drive shaft. In the second position, drive element **116** is arranged to transmit torque from the output of the torque converter to the drive shaft.

The clutch assembly includes one-way clutch functionality (for example, clutch **168** described below) and bi-directional clutch functionality (for example, clutch **170** described below). In an example embodiment, in the first position, the clutch assembly and drive element **114** are arranged to prevent rotation of the drive shaft in direction **RD1** and direction **RD2**, opposite direction **RD1**. In an example embodiment, in the second position, the drive shaft is rotatable in direction **RD1** and the clutch assembly and drive element **116** are arranged to prevent rotation of the drive shaft in a direction **RD2**. Note that directions **RD1** and **RD2** as shown in the figures can be reversed.

In general, only one of the first or second drive elements or the electric machine drives the drive shaft at any one time. For example, in the first position, drive element **114** is transmitting torque to the drive shaft, the drive shaft is rotatable with respect to drive element **116**, and the electric machine is being driven by the drive shaft. For example, in the second position, drive element **116** is transmitting torque to the drive shaft, the drive shaft is rotatable with respect to drive element **114**, and the electric machine is being driven by the drive shaft. For example, in the third position, the drive shaft is rotatable with respect to both drive element **114** and drive element **116** and is driven by the electric machine.

In an example embodiment, the clutch assembly includes hub **118**, wedge plate pairs **122** and **124**, and engagement system **125**. In an example embodiment, system **125** includes keys **126** and **128**. In an example embodiment, the clutch assembly includes actuator **130** including solenoid **132**, selection element **134**, and spring **136**. In an example embodiment, the spring and portions of the selection element are located radially inside of the drive shaft. Wedge plates pair **122** includes wedge plates **122A** and **122B** with respective outer circumferences **138A** and **138B**, respectively, engaged with drive element **114**. For example, circumferences **138A** and **138B** are disposed in groove **142**, to restrain wedge plates **122A** and **122B** in an axial direction, while enabling at least some radial movement as described below. Wedge plates pair **124** includes wedge plates **124A** and **124B** with respective outer circumferences **140A** and **140B**, respectively, engaged with drive element **116**. For example, circumferences **140A** and **140B** are disposed in groove **144**, to restrain wedge plates **124A** and **124B** in an axial direction, while enabling at least some radial movement as described below.

In FIGS. **2** and **3**, the clutch assembly is in the third clutch position. The selection element is displacing the keys radially outward with respect to the hub such that wedge plate pairs **122** and **124** are non-rotatably connected to the hub. As a result, the wedge plate pairs are rotatable with respect to the drive elements and the drive shaft is rotatable with respect to the drive elements. In an example embodiment, hub **118** includes an outer circumferential surface with a

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plurality of circumferentially spaced ramps and wedge plate pairs **122** and **124** include respective inner circumferential surfaces with respective pluralities of circumferentially spaced ramps engageable with the ramps of hub **118**. When wedge plate pairs **122** and **124** do not rotate with respect to the drive hub, the ramps of hub **118** and the respective ramps of wedge plate pairs **122** and **124** do not rotate with respect to each other and the ramps of hub **118** do not engage with the respective ramps of wedge plate pairs **122** and **124** to radially outwardly expand wedge plate pairs **122** and **124**. Thus, wedge plate pairs **122** and **124** rotate with respect to drive elements **114** and **116**, respectively.

To attain the first clutch position, the selector element is displaced in direction **D1** such that key **126** disengages with wedge plate pair **122**, and contact between drive element **112** and wedge plate pair **122** rotates wedge plate pair **122** with respect to the hub to non-rotatably lock drive element **112** and with the hub. That is, the ramps for hub **118** and wedge plate pair **122** slide across each other, pushing wedge plate pair **122** radially outward to non-rotatably connect to drive element **114**. Key **128** non-rotatably connects wedge plate **124** and the hub such that the drive shaft is rotatable with respect to drive element **116**. That is, as described above, the ramps for hub **118** and wedge plate pair **124** do not rotate with respect to each other and wedge plate pair **124** is not expanded radially outward.

To attain the second clutch position, the selector element is displaced in direction **D2** such that key **128** disengages with wedge plate pair **124**, and contact between drive element **114** and wedge plate pair **124** rotates wedge plate pair **124** with respect to the hub to non-rotatably lock drive element **114** and with the hub. That is, the ramps for hub **118** and wedge plate pair **124** slide across each other, pushing wedge plate pair **124** radially outward to non-rotatably connect to drive element **116**. Key **126** non-rotatably connects wedge plate **122** and the hub such that the drive shaft is rotatable with respect to drive element **114**. That is, as described above, the ramps for hub **118** and wedge plate pair **122** do not rotate with respect to each other and wedge plate pair **122** is not expanded radially outward.

It should be understood that the clutch assembly is not limited to the particular components described above, in particular with respect to one-way clutch functionality. For example, components different from the drive elements, keys, wedge plate pairs, and key actuator described above can be used to implement the one-way clutch functionality.

The position of the clutch assembly can be selected to provide a desired drive arrangement for the accessory devices. For example, a particular rotational speed is desired for the drive shaft. The desired speed could be related to minimum power requirements or efficiency of operation of the accessory devices. Drive elements **114** and **116** are rotating at respective speeds. Drive system **100** is configured such that the first or second position for the clutch assembly is selected according to which position best meets the conditions associated with the desired rotational speed for the drive shaft. For example, the rotational speed of drive element **114** is closer to the desired rotational speed than the rotational speed of drive element **116** and the first clutch position is selected, or the rotational speed of drive element **116** is closer to the desired rotational speed than the rotational speed of drive element **114** and the second clutch position is selected.

As another example, the rotational speed of drive element **114** is less than the desired rotational speed, the rotational speed of drive element **116** is greater than the desired speed, and the second clutch position is selected, or the rotational

speed of drive element **116** is less than the desired rotational speed, the rotational speed of drive element **114** is greater than the desired speed, and the first clutch position is selected. As a further example, the clutch position associated with the lower of the rotational speeds for drive elements **114** or **116** can be selected. For example, if the rotational speed for element **114** is lower than the rotational speed for element **116**, the first clutch position is selected. Note that other criteria can be applied to selecting the first and second clutch positions.

In an example embodiment, drive element **114** is bi-directional. For example, torque can be transmitted from drive element **114** to the drive shaft, as when the vehicle is operating in a steady state mode (for example, cruising at highway speed and not accelerating or decelerating) or a deceleration mode (for example, when wheels are transmitting torque to the transmission). During some operating conditions (for example, launching from a stop light or pulling a trailer up a hill), torque from the electric machine may be transmitted from the drive shaft to drive element **114** to help propel the vehicle.

In an example embodiment, the torque converter includes a turbine, a pump, and a pump hub non-rotatably connected to the pump (not shown) and the torque converter output includes the pump hub.

In an example embodiment, the at least one accessory device includes a plurality of accessory devices. In an example embodiment, the at least one accessory device includes one or more of fuel pump **148**, engine oil pump **150**, vacuum pump **152**, air conditioning compressor **154**, water pump **156**, or transmission oil pump **158**.

The following provides further detail regarding system **100**. System **100** includes three-position selectable one-way clutch assembly **102** that connects, for example, a torque converter pump hub and a transmission output shaft to accessory devices **106**. For example, the clutch assembly includes respective one-way clutch functionality associated with torque input from the pump hub and from the output shaft. Thus, in the first clutch position, the accessory devices, are driven the speed of engine **103** (connected to the torque converter by crankshaft **105** and connection **109**) by cover **111** and in the second clutch position, the accessory devices are driven by output shaft **121**, for example when decelerating or when a vehicle housing system **100** is operating at highway speed. In the third clutch position, the accessory devices are disconnected from the drive shaft and are driven by the electric machine, for example, when the vehicle is accelerating or when the engine is shut off.

In an example embodiment, torque converter clutch **166** is connected to cover **111**. Drive element **114**, wedge plate pair **122**, key **126**, and hub **118** form one-way clutch **168**. Drive element **116**, wedge plate pair **124**, key **128**, and hub **118** form one-way clutch **170**. In an example embodiment, drive pulley **172** is non-rotatably connected to drive shaft **104** to drive accessory devices **106**. For example, pulley **172** drives one of devices **106** via belt **174**. Belts **174A-G** are shown in FIG. 4. Alternatively, pulley **172** may drive two or more of devices **106** via a serpentine belt, as is known in the art.

In an example embodiment, drive element **114** is connected to the transmission output shaft by chain or belt **119**, creating a ratio of 0.65. In an example embodiment, drive element **116** is connected to cover **111** by chain or belt **125** creating a ratio of 1:1. It should be understood that other ratios are possible.

FIG. 5 is a schematic block diagram of a vehicle with accessories drive system **200**. In an example embodiment,

vehicle **202** includes accessories drive system **200**, engine **204**, starter **206**, crankshaft **208**, transmission **210**, and differential/wheels **212**. System **200** includes clutches **214**, **216**, and **218**, at least one accessory device **220**, electric machine **222**, and drive shaft **224**. Clutch **218** is a friction clutch. Clutches **214** and **216** can be dog clutches, friction clutches, or switchable one-way clutches. In an example embodiment, the descriptions of clutches **168** and **170** are applicable to clutches **216** and **214** when clutches **216** and **214** are switchable one-way clutches. The discussion regarding devices **106** is applicable to device(s) **220**. Example ratios of 2.5:1 and 1:2 are shown between the electric machine and drive shaft **224** and between clutch **214** and drive shaft **224**, respectively; however, it should be understood that other ratios are possible.

The discussion regarding vehicle **101** and system **100** is generally applicable to vehicle **202** and system **200**. For example, in the first mode of operation for the vehicle, the at least one accessory device is driven by the engine at a rotational speed for the crankshaft. In a second mode of operation for the vehicle, the at least one accessory device is driven by the transmission at a rotational speed of one of the shafts of transmission **210**.

In an example embodiment, accessories drive system **200** is connected to crankshaft **208** and one of the shafts of the transmission, such as input shaft **226**, output shaft **228**, or counter shaft, layshaft or concentric shaft **230**, for example, within the transmission. The at least one accessory device **220** is connected to the drive shaft. In the first mode of operation for the vehicle, the accessories drive system is arranged to transmit first torque from one of the shafts of the transmission to the drive shaft to drive the at least one accessory device while rotation of the drive shaft is isolated from rotation of a crankshaft. In the second mode of operation, the accessories drive system is arranged to transmit second torque from crankshaft **208** to the drive shaft to drive the at least one accessory device while the rotation of the drive shaft is isolated from rotation of the shaft for the transmission.

FIG. 6 is a cross-sectional view of a connection to an input shaft of a transmission for an accessories drive system.

FIG. 7 is a schematic block diagram of a vehicle with accessories drive system **300**. FIGS. 6 and 7 illustrate an arrangement to provide torque from input shaft **301** of a transmission. In FIG. 6, chain or belt **125** is connected to pump hub **302** for torque converter **304** (only partially depicted). Chain or belt **125** is contained in housing **306**. Passages **308** and **310** are apply and release pressure hydraulic passages for operation of the torque converter. Chain or belt **119** is connected to a sprocket on input shaft **300**. Housing **312** supports bearing **314** which supports gears in the transmission (not shown).

In an example embodiment, vehicle **316** includes accessories drive system **318**, engine **320**, starter **322**, crankshaft **324**, transmission **326**, and differential/wheels **328**. System **300** includes clutches **330**, **332**, and **334**, at least one accessory device **336**, electric machine **338**, and drive shaft **340**. Clutch **334** is a friction clutch. Clutches **330** and **332** can be dog clutches, friction clutches, or switchable one-way clutches. In an example embodiment, the descriptions of clutches **168** and **170** are applicable to clutches **332** and **330** when clutches **332** and **330** are switchable one-way clutches. The discussion regarding devices **106** is applicable to device(s) **336**.

Using chain or belt **119** and the connection to the input shaft of the transmission, when the vehicle is coasting to a stop, all the speeds of the transmission can be used to drive

the accessories. For example, there is a fixed ratio between differential and wheels **328** and output shaft **342**. During coasting the rotational speed of the output shaft falls below minimum accessory drive speed very quickly as the wheels decelerate, such that accessory devices **336** cannot be driven by the output shaft. However, in coast, input shaft **344** rotates at a speed determined by gears engaged in transmission **326**. Therefore, all the gear ratios in transmission **326** are available to control the rotational speed of the input shaft. Thus, in coast, when the rotation of the output shaft is too low, the transmission can be shifted to increase the rotational speed of the input shaft such that the rotational speed of the input shaft is adequate to drive the accessory devices.

In an example embodiment (not shown), a one-way clutch is present between a turbine for torque converter **304** and input shaft **344**. The one-way clutch enables the turbine to drive the vehicle but not to back-drive the engine in coast. This would enable all kinetic energy to go into the accessory devices.

The following provides further detail regarding vehicles **101/202/302** and systems **100/200/300**. Although the following discussion is directed to vehicle **101** and system **100**, it should be understood that the discussion is applicable to vehicle **202/302** and system **200/300** as well. In an example embodiment, the accessory devices associated with operation of the engine, such as the water pump and air conditioner compressor, are located in an engine compartment. In an example embodiment, the accessory devices associated with operation of the engine, such as the water pump and air conditioner compressor, are located at or in the transmission.

In an example embodiment, transmission oil pump **158** is moved off-axis, for example, not directly driven by a torque converter pump hub, and connected through the clutch assembly, which advantageously enables use of a smaller pump providing full transmission pressure during sailing (engine off highway cruising). In an example embodiment, engine oil pump **150** is connected to system **100** to advantageously pressurize an oil system for the vehicle with the engine off, for example, to adjust a hydraulic vane-type variable cam timing (VCT) system for startup.

Thus, system **100** enables accessory devices to be driven at lower speeds during normal operation of the vehicle and to be driven while the engine is off. Further, system **100** enables accessory devices to be driven by the electric machine when the engine is off or when the vehicle is accelerating. System **100** also enables the vehicle to be hybridized by enabling use of a larger capacity electric machine and battery system in a conventional vehicle. Thus, system **100** enables multiple levels of hybridization by enabling increased sizing of the electric machine and battery. As a result, system **100** enables a modular hybrid strategy with one base power train.

System **100** provides several advantages for modern vehicle drivetrains. The system is an enabler for stop-start strategies in which the vehicle engine is turned off while approaching or waiting at a traffic light, for example. Because system **100** allows the electric machine to drive accessories with the engine off (i.e., the third clutch position), the cabin stays comfortable because the air conditioner is still functional, the engine oil pump can pressurize the variable cam timing system for optimum restart, and the engine will restart faster because the inertia of the accessory drive is removed.

The system also solves problems with turning the engine off when the vehicle is cruising on a highway, sometimes referred to as sailing. An output shaft driven transmission oil

pump (i.e., the first clutch position) enables full hydraulic clutch control, including gear shifts, in the transmission, and a driven vacuum pump ensures vacuum boosted brakes remain operational for safety. In addition, downspeeding the accessories through chain or belt ratios and/or connection to the transmission output shaft reduces drag on the drivetrain. The same output shaft connection allows kinetic energy recovery to recharge the battery and drive the aforementioned accessories without using engine or battery power during deceleration.

The system also includes one-way clutch functionality when the engine is driving the accessories (i.e., the second clutch position). The one-way clutch decouples the accessory devices from engine vibration, since the one-way clutch function only transmits engine torque in one rotational direction. Thus, the slowing of the crankshaft between cylinder firings, which can create vibration and reduce operational efficiency, is not transmitted to the drive shaft. For example, in response to the slowing, drive element **116** free wheels rather than transmitting torque to the drive shaft.

It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Various presently unforeseen or unanticipated alternatives, modifications, variations, or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

The invention claimed is:

1. An accessories drive system for a vehicle, comprising:

a clutch assembly including:

a drive shaft;

a first drive element

a first key;

at least one first wedge plate radially located between the first key and the first drive element

a second drive element

a second key;

at least one second wedge plate radially located between the second key and the second drive element and,

at least one accessory device connected to the drive shaft, wherein:

in a first position for the clutch assembly:

the clutch assembly is arranged to axially displace the first key;

the at least one first wedge plate is arranged to displace radially outward;

the clutch assembly is arranged to transmit first torque from a shaft for a transmission through the at least one first wedge plate, to the drive shaft to drive the at least one accessory device; and,

rotation of the drive shaft is isolated from rotation of a crankshaft for the vehicle; and,

in a second position for the clutch assembly:

the clutch assembly is arranged to axially displace the second key;

the at least one second wedge plate is arranged to displace radially outward;

the clutch assembly is arranged to transmit second torque from the crankshaft, through the at least one second wedge plate, to the drive shaft to drive the at least one accessory device; and,

the rotation of the drive shaft is isolated from rotation of the shaft for the transmission.

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2. The transmission accessories drive system of claim 1, further comprising an electric machine, wherein in a third position for the clutch assembly:

the drive shaft is rotatable with respect to the shaft for the transmission and the launch device; and,

the electric machine is arranged to drive the at least one accessory device.

3. The transmission accessories drive system of claim 1, wherein:

the first drive element is connectable to the shaft for the transmission;

the second drive element is connectable to the crankshaft; in the first position, the first drive element is arranged to transmit the first torque from the shaft for the transmission to the drive shaft; and,

in the second position:

the second drive element is arranged to transmit the second torque from the crankshaft to the drive shaft.

4. The transmission accessories drive system of claim 3, further comprising an electric machine, wherein in a third position:

the drive shaft is rotatable with respect to the first and second drive elements; and,

the electric machine is arranged to rotate the drive shaft.

5. The transmission accessories drive system of claim 3, wherein the first or second position is selectable according to a desired rotational speed for the drive shaft.

6. The transmission accessories drive system of claim 3, wherein:

one of the shaft for the transmission or the crankshaft is rotating at a speed closer to a desired speed for the drive shaft than the other of the shaft for the transmission or the crankshaft; and,

the clutch assembly is arranged to operate in the first or second clutch position corresponding to the one of the shaft for the transmission or the crankshaft.

7. The transmission accessories drive system of claim 3, wherein the clutch assembly is arranged such that:

third torque is transmittable from the first drive element to the drive shaft; and,

fourth torque is transmittable from the drive shaft to the first drive element.

8. The transmission accessories drive system of claim 3, wherein:

the clutch assembly includes a drive hub non-rotatably connected to the drive shaft;

the at least one first wedge plate includes an outer circumference engaged with the first drive element;

the at least one second wedge plate includes an outer circumference engaged the second drive element; and,

the clutch assembly includes an engagement system; to attain the first position the engagement system is operable such that:

the at least one first wedge plate rotates with respect to the drive hub to non-rotatably connect the first drive element and the drive hub; and,

the at least one second wedge plate is rotatable with respect to the second drive element; and,

to attain the second position the engagement system is operable such that:

the at least one second wedge plate rotates with respect to the drive hub to non-rotatably connect the second drive element and the drive hub; and,

the at least one first wedge plate is rotatable with respect to the first drive element.

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9. The transmission accessories drive system of claim 8, wherein:

the engagement system includes:

the first key, the first key engageable with the at least one first wedge plate and the drive hub; and,

the second key, the second key engageable with the at least one second wedge plate and the drive hub, the drive system further comprising:

an actuator including:

a selection element engageable with the first and second keys;

a spring engaged with the selection element and urging the selection element in a first axial direction; and,

a solenoid arranged to displace the selection element in a second axial direction, opposite the first axial direction.

10. The transmission accessories drive system of claim 9, wherein the spring and at least a portion of the selection element are located within an interior space of the drive shaft.

11. The transmission accessories drive system of claim 9, wherein, the solenoid and the spring are arranged to axially displace the selection element such that:

the first and second keys are non-rotatably connected to the at least one first and second wedge plates, and the at least one first and second wedge plates are rotatable with respect to the first and second drive elements, respectively;

the first key is non-rotatably connected to the at least one first wedge plate, the at least one first wedge plate is rotatable with respect to the first drive element, and the at least one second wedge plate is non-rotatably connected to the second drive element and to the drive shaft; and,

the second key is non-rotatably connected to the at least one second wedge plate, the at least one second wedge plate is rotatable with respect to the second drive element, and the at least one first wedge plate is non-rotatably connected to the first drive element and to the drive shaft.

12. The transmission accessories drive system of claim 11, wherein the solenoid and the spring are arranged to axially displace the selection element such that:

the first and second keys are displaced radially outward to non-rotatably connect to the at least one first and second wedge plates, respectively;

the first key is displaced radially outward to non-rotatably connect to the at least one first wedge plate; and,

the second key is displaced radially outward to non-rotatably connect to the at least one second wedge plate.

13. The transmission accessories drive system of claim 1, wherein:

the crankshaft is non-rotatably connected to a launch device such that in the second position for the clutch assembly:

the clutch assembly is arranged to transmit second torque from the launch device to the drive shaft to drive the at least one accessory device; and,

the rotation of the drive shaft is isolated from rotation of the shaft for the transmission.

14. The transmission accessories drive system of claim 13, wherein:

the launch device includes a torque converter with a cover, a turbine, and a pump non-rotatably connected to the cover;

in the first position for the clutch assembly, rotation of the drive shaft is isolated from rotation of the cover; and,

in the second position for the clutch assembly, the clutch assembly is arranged to transmit the second torque from the cover to the drive shaft to drive the at least one accessory device.

15. The transmission accessories drive system of claim 1, 5 wherein the at least one accessory device is selected from the group consisting of a fuel pump, an engine oil pump, a vacuum pump, an air conditioning compressor, a power steering pump, a water pump, and a transmission oil pump.

16. The transmission accessories drive system of claim 1, 10 wherein the at least one accessory device includes a plurality of accessory devices.

17. The transmission accessories drive system of claim 1, wherein the shaft for the transmission is selected from the group consisting of an input shaft, a counter shaft, an output 15 shaft, a concentric shaft and a layshaft.

18. The transmission accessories drive system of claim 1, wherein:

the first drive element is connected to the shaft for the transmission by a chain or belt creating a ratio of 0.65; 20 or,

the second drive element is connected to the crankshaft by a chain or belt creating a ratio of 1:1.

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